Private Sector Investment in Pakistani Agriculture

The Role of Infrastructural Investment

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ABSTRACT

By all accounts, Bank, Pakistan faces increased difficulties in expanding its agricultural sector. For its part, the government is gradually withdrawing from its historical policy of direct intervention and adopting a more market oriented strategy. In this strategy, the private sector will be expected to play the major role in providing capital to the agricultural sector, with government's remaining involvement being largely one of furnishing basic infrastructure. The purpose of this paper is to assess the willingness of the private sector to commit capital to agricultural activities in this new policy environment. In this regard, it appears that if infrastructure is to make a contribution to the country's agricultural sector, it will most likely be in terms of improved quality of facilities and efficient management rather than their simple expansion.

Introduction

OVER THE PAST DECADE and a half, Pakistan's agriculture sector has undergone major technological and policy transformations. By introducing technical changes, offering production incentives, and increasing the availability of fertilizer, water, and credit, Pakistan has increased its exportable surplus of cotton and is close to self-sufficiency in wheat. The sector accounts for roughly 30 percent of the country's exports. During the Sixth Five-Year Plan (FY84-88) agriculture grew at 3.8 percent compared with a target of 4.9 percent. During the 1980-93 period as a whole however, the sector experienced an expansion of 4.4 percent per annum in food production with per capita food production increasing at a rate of 1.2 percent. Comparable figures for the same period for low income countries as a whole were 3.4 and 1.3 percent (IBRD 1995). It should be noted, however, that year-to-year growth is often sensitive to developments in the cotton sector (Bokhari

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1996), and that the sector's contribution to overall growth has generally been less than that of manufacturing (Looney 1994d).

Despite the sector's relatively good aggregate performance, a consensus is now emerging (IBRD 1991) that argues that the prospects for sustaining the rate of expansion that was achieved in the 1990s will become increasingly limited unless the Government is able to effectively address a number of fundamental sector issues. These include: poor crop yields and productivity; inadequately funded and poorly managed support services and institutions; serious water resource management issues; long standing land-tenure problems; and inappropriate pricing policies.

Many of these issues are currently being addressed, with the government gradually withdrawing from its historical policy of direct intervention and adopting a more market oriented strategy. For its part, the private sector will be expected to play the major role in providing capital to the sector, with the government's remaining involvement largely being one of furnishing basic infrastructure (Looney and Winterford 1992).

The critical question of course is how willing is the private sector to commit capital to agricultural activities in this new policy environment? Has the private sector responded in the past to the increases in profitability provided by an expansion in infrastructure? If so, what types of infrastructure are most conducive in this regard? Have there been any offsetting effects associated with other government programs? The purpose of this paper is to examine these issues.

Historical Evolution

At the time of independence, Pakistan was predominantly agricultural (Hamid and Nasim 1990). In 1950, agriculture accounted for 53 percent of Gross National Product (GNP). Since then, the share of agriculture in GNP has declined steadily, and in 1988 it was just under 24 percent. The agricultural sector growth rate has fluctuated considerably during this period. Shortly after independence, a strategy of industrialization based on import substitution was launched which involved a large implicit tax on agriculture. As a result, industry expanded while agriculture stagnated, (agriculture growth rate was only 1.6 percent in the 1950s).

Attempts were made to promote agricultural growth by Ayub Khan's government in the 1960s. Large scale public investment was undertaken in the Indus Basin Replacement Works, and the Salinity Control and Reclamation Projects (SCARPs). Simultaneously, land reforms were also introduced. The result was that agriculture registered a growth rate of 3.2 percent per annum between FY 1961 and FY 1965, and after the introduction of high yield varieties of wheat and rice, agriculture growth increased even further (growth rate for the early period of the Green Revolution i.e., from 1967 to 1970 was 7.8 percent per annum). In the 1970s agri-

culture once again went through a period of relative stagnation (the growth rate for the period 1971 to 1978 was 1.7 percent per annum), but the trend in agricultural growth reversed once again, and as noted above, the sector has expanded to around 4 percent per annum in recent years.

While the overall growth performance is impressive it should be noted that: (Khan 1985:306)

1. The growth performance has not been shared equally even by the four major crops: wheat, rice, cotton and sugar-cane. Wheat and rice have continued to show a stable growth in the yield levels, but cotton and sugar-cane have been subject to wide fluctuations. In fact, the sugar-cane yields have been stagnant or even falling.
2. The livestock sector is still highly fragmented and inefficient. The exception is the emergence of a somewhat well-organized poultry industry around major urban centers. A similar development is now under way in the dairy industry.
3. Regional disparity between irrigated and rain fed area is not only high but perhaps even increasing. Development of land-saving technology for increased yield levels has not been observed in the rain-fed areas simply because of lack of assured supply of water and adequate research funding.
4. Finally and perhaps most importantly, the impact of growth on the various classes engaged in agriculture has been highly uneven. Poverty afflicts millions in Pakistan. Most of the poor live in rural areas working on or around land. The rural poor are mostly in households of sharecroppers and landless (casual) laborers. Landlessness is perhaps the most important indicator of rural poverty. There is also considerable poverty even among the small owner-operators in the Punjab and the NWFP, particularly in the rain-fed regions.

The green revolution which transformed Pakistani agriculture in the last two decades depended not only on modern inputs, but also on physical infrastructure such as the provision of irrigation. Mechanization, land development and soil conservation schemes along with transport and communication facilities have also played a role in bringing about high growth in the agricultural sector. As is well known, the application of fertilizer input can be effective only if an adequate and continued supply of water is available through irrigation (ESCAP 1991). Further, and to varying degrees throughout the country, soft infrastructure including research, extension, and the provision of institutional credit and marketing services have enhanced agricultural productivity.

The irrigated land area in Pakistan grew at an average annual rate of 0.9 percent per annum during the 1978 to 1988 period. This was somewhat below the 1.9 percent rate for the South Asian region as a whole. However within the region, Pakistan began this period with the highest percentage (71.4 percent) of land under irrigation. The sector’s infrastructure, while extensive is extremely inefficient (IBRD 1994a) in that (Beg 1995b p. 14): (1) the delivery system leads to

evaporation losses to the extent of 20 to 24 million acre feet (MAF) and seepages account for the loss of another 40 to 50 MAF; (2) drainage to retard waterlogging and salinity is insufficient, resulting in the loss of 28 percent of the country's agricultural land; (3) water is shared inequitably with huge excesses by landlords in the upper reaches of the distributary command area, cutting use of the tail-enders by 80 percent of their legitimate share; and (4) lack of soil and water conservation practices causes erosion of sediment and silting of dams and conveyance channels.

Because of the high rate of population growth and the slow absorption of labor in the nonagricultural sectors, the amount land per agricultural worker declined at an annual rate of 3.2 percent. For South-Asia as a whole the comparable figure was an increase of 0.2 percent per annum.

In terms of its commitment to agricultural research, the Government has allocated around 0.41 percent of the country's income to this activity. This is less than that for the region as a whole.

Agricultural Policy Problems

Through the 1970s, inappropriate sector pricing and marketing policies constituted a further constraint on efforts to improve productivity and provide adequate incentives to producers. Initially, the Government's main objective in regulating agricultural prices was to keep the cost of food low for urban consumers, while providing cheap raw materials for domestic industry. Subsequently, recognizing the need to minimize the heavy transfer of resources out of agriculture, the government acted to balance the low output prices with subsidized inputs, such as fertilizer, while also keeping the price of water, fuel and power low. This structure of controlled pricing, heavy input subsidies and costly public sector marketing arrangements resulted in an increasingly heavy drain on public finances during the 1960s and 1970s, which in turn prompted a major revision of Government policies in the sector beginning in the early 1980s.

The revised agricultural sector strategy which the Government announced at the beginning of the 1980s emphasized (Looney 1994a) the need to promote irrigation rehabilitation rather than new investments, bring input and output prices closer to world market levels, reduce public expenditures and enhance the role of the private sector. These objectives were to be achieved by: (IBRD 1991:22)

1. Reorienting public investment priorities to focus on rehabilitating irrigation infrastructure, upgrading on farm water management, and enhancing agricultural research and extension capacity.
2. Aligning input and output prices with resource costs, with reference to international prices, and gradually removing subsidies; and

3. Providing incentives to the private sector to actively participate in the input and output marketing and distribution, the processing of grain, and the exploitation of fresh groundwater.

These revised sector objectives were confirmed in the Policy Framework Paper (PFP) issued in 1988. The PFP stressed the importance of enhancing productivity through adequate funding of investment and appropriate price incentives for farmers. Priority was to be given to accelerating privatization of tubewells in fresh groundwater areas, adjusting support prices, promoting private sector participation in rice and cotton exporters, removing the subsidy on fertilizer as well as all distribution controls, and ensuring full recovery of operations and maintenance costs for irrigation and drainage systems (IBRD 1991).

Beginning in the early 1990s, most of the Government's subsidy programs for pesticides, seeds, and mechanization were in the process of being dismantled. With respect to fertilizer subsides, significant price increases have been implemented over the past three years, with the most recent in October 1990. Consequently, fertilizer subsidies have been largely eliminated and phasing out of the remaining subsidy is on track. Good progress has also been made in privatizing public tubewells. All of the public tubewells under the IDA assisted SCARP Transition Pilot Project have now been phased out. The Government has also moved to reduce market controls: permitting private traders to sell wheat, cotton, basmati rice, oilseeds and sugarcane at competitive market prices; allowing the private sector to enter the export trade in rice and cotton; and significantly reducing consumer subsidies by abolishing Government wheat flower rationing and sugar ration shops.

Despite the high pay-offs to economic liberalization, the fact remains that the process has proceeded unevenly across the various sectors (Chaudhry 1995). Except for the removal of input subsidies, practically nothing but mere lip service has happened in agriculture. The revival of the private markets is not in sight, agricultural commodity markets remain dominated by monopolies or government parastatals, and the Government continues to fix prices at less than world levels to serve the interest of politically volatile urban consumers and a powerful class of industrialists. A large body of literature has accumulated showing that prices of agricultural commodities in Pakistan have only been half of those in the world, resulting in immense resource transfers exceeding billions of rupees each year from agriculture to the rest of the economy. Additional stress will be placed on the sector once the Government begins to implement its long anticipated agricultural tax (Islam and Rashid 1996; Bokhari 1996a, 1996b).

Impact of Infrastructure Investment on Private Investment

While the Government is [(budgetary circumstances allowing)] committed to providing additional infrastructure to aid the private sector in agriculture, much

of the current literature (Leff and Sato 1980), on private sector investment in developing countries tends to argue that public investment involves both the development of infrastructure, which likely would be complementary with private investment, and other types of consumption and noninfrastructural investment which may compete with private investment. The latter could occur either through absorbing limited physical resources or through the production of marketable output. In the aggregate, the effects of the infrastructural and noninfrastructural components can offset each other, thereby yielding the impression that the impact of total government investment on the level of private investment is weak or insignificant (Looney 1992a).

It can be shown (Blejer and Khan 1985), however, that once the two aspects of public sector investment are recognized the picture becomes much clearer. Here, the key is to distinguish public sector expenditures along functional lines involving infrastructural and noninfrastructural investment and consumption. Once this delineation is made, considerably stronger statements can be made of the role of government in private capital formation.

Following this approach, the model developed below is a neo-classical variant of the standard accelerator model, adapted to incorporate some of the institutional and structural characteristics of the Pakistani economy.

As a starting point, it is reasonable to assume that private investors in Pakistan undertake investment to bridge the gap between their actual capital stocks and perceived optimal levels. Following Blejer and Kahn (1985) we assume the process takes place as follows:

$$\Delta IP_t = b[IP_t^* - IP_{t-1}] \tag{1}$$

Where IP^* is the desired level of gross private investment; IP is the actual level of gross private investment; b is the coefficient of adjustment with b greater than or equal to 0 (and less than or equal to 1); and Δ is a difference operator in the steady state. The desired rate of gross private investment can be related to the desired stock of private capital KP^* in the following manner:

$$IP_t^* = [1 - (1 - z)L]KP_t^* \tag{2}$$

Where z is the rate of depreciation and L is a lag operator — $LKP_t = KP_{t-1}$.

In the long-run representation of the simple accelerator model, the desired stock of capital can be assumed to be proportional to lagged output, YR_{t-1}:

$$KP_t^* = aYR_{t-1} \tag{3}$$

Combining equations 1 to 3 and solving for IP_t yields the basic dynamic accelerator function:

$$IP_t = [1 - (1 - z)L]baY_{t-1} + (1 - b)IP_{t-1} \tag{4}$$

As for the role of public investment and other factors in the rate of private capital formation, we hypothesize that the response of gross private investment to the gap between desired and actual investment, as measured by b in equation (1) is not a fixed parameter, but rather varies systematically with economic factors that influence the ability of private investors to achieve the desired level of investment.

We assume the ability to respond on the part of the private sector depends on the general ease or tightness of financial markets (Schiantarelli 1996). The rudimentary nature of capital markets in Pakistan, however, limits the financing of private investment to the use of retained profits, bank credit and, in particular, government subsidies. An increase in real credit to the private sector will, other things being equal, directly encourage real private sector investment, and by automatically extending short-term bank loans the maturity of debt can be lengthened sufficiently to correspond to the length of the investment project.

Obviously many of these factors are related to government actions. In addition, many of the government's policies work at cross purposes. Government subsidies for example may facilitate private sector investment, but government borrowing to finance these programs may compete with the private sector for scarce domestic savings (Looney 1995). Operationally, we assume these effects are captured by the lagged public budget deficit:

$$b_t = bo + \frac{1}{[IP_t^* - IP_{t-1}]}[b1\Delta CR_{t-1} + b2GI_t] \tag{5}$$

Where ΔCR is the change in credit to the agricultural sector and GI represents real government investment. Equation (5) states that the response of private investment depends on the magnitude of the two factors measured in relative terms with respect to the size of the discrepancy between desired and actual investment $[IP_t^* - IP_{t-1}]$. The signs of the parameters in this equation are expected to be: b1 greater than 0; b2 less than or greater than zero.

Substituting equation (5) into equation (1) yields:

$$IP_t = bo[IP_t^* - IP_{t-1}] + b1\Delta CR_{t-1} + b2GI_t \tag{6}$$

Since from equations (2) and (3) we show that

$$IP_t^* = boa[YR_{t-1} - YR_{t-2}] + b1\Delta CR_{t-1} + b2Gi_t + (1 - bo)IP_{t-1}$$

we can now derive a dynamic reduced form equation for gross private investment

$$IP_t = boa[YR_{t-1} - (1 - c)YR_{t-2}] + b1\Delta CR_{t-1} + b2GI_t + (1 - bo)IP_{t-1} \tag{7}$$

The effects of government policy on private investment can be directly obtained from the estimates of b1 and b2.

Normally we should expect a large proportion of the variance in private investment to be accounted for by this factor. On the other hand, since it is

always possible that the infrastructural and noninfrastructural components of public investment offset each other (financial competition crowding out some private investment), it is makes sense to separate and estimate the independent effects of the different categories of public investment. Unfortunately, it is not possible, given the existing data on government expenditures in Pakistan, to make such functional distinctions.

One way of getting around this problem is to develop alternative proxies for infrastructural and noninfrastructural components. The basic assumption underlying these proxies is that infrastructure investment is an ongoing process that moves slowly over time and cannot be changed very rapidly. The first of the two approaches takes the trend level of real public sector investment as representing the long-term or infrastructural component and argues that this should have a positive effect on gross real private investment. Deviations from the trend are assumed to represent noninfrastructural investment (Blejer and Khan 1985).

A variant on this approach is to proxy infrastructure as the predicted value of investment obtained through regressing each measure of public investment on its lagged value. Again, it is assumed that the predicted or expected value of public investment, GIE, reflects longer-term movements in the infrastructural component of public investment. However, the effect of unanticipated levels of investment may result in crowding out. Incorporating these considerations into the basic model yields:

$$\begin{aligned} IP_t = {} & boa[YR_{t-1} - YR_{t-2}] + b1\Delta CR_{t-1} + b2GIE_t \\ & + b3[GI_t - GIE_t] + (1 - bo)IP_{t-1} \end{aligned} \tag{8}$$

Where: unexpected expenditures ($GIU_t = GI_t - GIE_t$) are assumed to be the difference between actual expenditures and expected expenditures. A negative sign for b3 would be indicative of real crowding out. Both measures of infrastructure/noninfrastrucucute: (a) trend in public investment and the deviation from that trend and (2) expected/unexpected investment produced similar results. For brevity, only those using, the expected/unexpected investment proxies for infrastructure are presented in Table 1.

The data for investment upon which the infrastructure expenditures were calculated were derived from World Bank estimates (IBRD 1983, 1991, 1992, 1993) and those of the Pakistani Government (GOP 1995). Public credit for agriculture is proxied by credit from the Agricultural Development Bank of Pakistan and is taken from the *Economic Survey* (GOP 1995). Gross Domestic Product and the GDP price deflator is from the International Monetary Fund, *International Financial Statistics*. All variables were deflated by the GDP deflator and are in constant 1990 prices.

Results

The main findings are presented in Table 1, where two sets of results, one for investment and one for infrastructure were estimated for each type of government activity examined:

1. By themselves, lagged private investment, and the lagged changes in GDP and agricultural credit from the Agricultural Development Bank account for around 95 percent of the movement in private investment in agriculture.
2. Public investment (largely rural works programs) in agriculture does not stimulate investment in agriculture. This term (equation 2) had a negative sign, but was statistically insignificant.
3. On the other hand when rural works programs are examined in terms of their infrastructural and noninfrastructural components (equation 3), it appears that increases in noninfrastructural activities discourage private investment.
4. The other major government program focused on agriculture, the Indus Basin authority does not provide a stimulus for the private sector (equations 4 and 5).
5. On the other hand public investment in power, particularly that falling in the infrastructure category as defined here provides a strong stimulus to the private sector (equations 6 and 7).
6. Investment in the rail sector produced (equations 8) a generally negative impact on private investment in agriculture, again this was especially the case (equation 9) with the noninfrastructural component.
7. Finally, general federal infrastructure had the same pattern noted several times previously. That is, while investment of this type had a negative, albeit statistically insignificant impact on private investment, the noninfrastructural component had a negative effect on private investment.

Interpretations

A complete explanation for these patterns is beyond the scope of this study. However it should be noted that these findings are consistent with two other bodies literature on the Pakistani economy. The first (Khan 1988; Khan and Iqbal 1991; Looney 1992) involves the problem (noted above) of private sector “crowding-out” in that country. Briefly this literature (Looney 1995a) often finds that increased government expenditures, either through real crowding-out (the preemption of scarce resources) or financial crowding-out (the government’s preemption of financial resources) is becoming an increasing problem in that country. The belief that crowding-out is likely to be more prevalent in the short-run with surges in government expenditures, is consistent with the negative sign on many of the public noninfrastructural components found above.

The second involves the evolution of the agricultural sector itself, with implications for the effectiveness of various inputs in increasing that sector’s output.

Table 1

Pakistan: Factors Affecting Private Sector Investment in Agriculture

Private Investment Agriculture (IPAGP)

(1) $IPAG = 1.15 + 0.83\ IPAG_{t-1} + 0.12\ \Delta Y_{t-1} + 0.33\ \Delta ADB_{t-1}$
(3.32) (12.91) (1.07) (2.29)

Std. error of regression = 0.463 R-squared = 0.958 Adjusted R-squared = 0.951
Rho (autocorrelation coef.) = −0.233 t-statistic for rho = −0.922

Public Works Investment in Agriculture (IGAG) Component

(2) $IPAG = 1.14 + 0.83\ IPAG_{t-1} + 0.12\ \Delta Y_{t-1} + 0.34\ \Delta ADB_{t-1} - 0.08 IGAG$
(2.08) (6.58) (0.89) (2.13) (−0.04)

Std. error of regression = 0.470 R-squared = 0.959 Adjusted R-squared = .947585
Rho (autocorrelation coef.) = −0.236 t-statistic for rho = −0.836

Public Works Infrastructure (I-AG) and Noninfrastructure (NI-AG) in Agriculture

(3) $IPAG = 1.15 + 0.84\ IPAG_{t-1} + 0.29\ \Delta Y_{t-1} + 0.25\ \Delta ADB_{t-1} + 0.14\ I\text{-}AG - 0.70\ NI\text{-}AG$
(2.83) (8.85) (0.23) (1.82) (0.80) (−2.02)

Std. error of regression = 0.428 R-squared = 0.976 Adjusted R-squared = 0.967
Rho (autocorrelation coef.) = −0.390 t-statistic for rho = −1.49225

Indus Basin Investment (IGIB)

(4) $IPAG = 0.27 + 0.92\ IPAG_{t-1} + 0.14\ \Delta Y_{t-1} + 0.38\ \Delta ADB_{t-1} + 0.28\ IGIB$
(0.21) (6.85) (0.95) (2.20) (0.72)

Std. error of regression = 0.469 R-squared = 0.955 Adjusted R-squared = 0.942
Rho (autocorrelation coef.) = −0.161 t-statistic for rho = −0.529749

Indus Basin Infrastrucure (I-IB) and Noninfrastructural component (NI-IB)

(5) $IPAG = 0.14 + 0.93\ IPAG_{t-1} + 0.14\ \Delta Y_{t-1} + 0.38\ \Delta ADB_{t-1} + 0.33\ I\text{-}IB + 0.27\ NI\text{-}IB$
(0.08) (5.21) (0.93) (2.12) (0.61) (0.64)

Std. error of regression = 0.485 R-squared = 0.956 Adjusted R-squared = 0.940
Rho (autocorrelation coef.) = −0.175636 t-statistic for rho = −0.482163

Energy Investment (IGE)

(6) $IPAG = 1.65 + 0.68\ IPAG_{t-1} + 0.12\ \Delta Y_{t-1} + 0.46\ \Delta ADB_{t-1} + 0.57\ IGE$
(3.16) (5.32) (1.08) (3.05) (1.83)

Std. error of regression = 0.417 R-squared = 0.968 Adjusted R-squared = 0.960
Rho (autocorrelation coef.) = −0.230 t-statistic for rho = −0.85

Energy Infrastructure (I-E) and Noninfrastructural Component (NI-E)

(7) $IPAG = 1.64 + 0.58\ IPAG_{t-1} + 0.24\ \Delta Y_{t-1} + 0.66\ \Delta ADB_{t-1} + 0.79\ I\text{-}E - 0.04\ NI\text{-}E$
(4.29) (5.74) (2.09) (3.98) (2.95) (−0.66)

Std. error of regression = 0.388 R-squared = 0.980 Adjusted R-squared = 0.973
Rho (autocorrelation coef.) = −0.388 t-statistic for rho = −1.50

Table 1

(Continued)

Railroad Investment (IGR)

(8) $IPAG = 2.11 + 0.80\ IPAG_{t-1} + 0.12\ \Delta Y_{t-1} + 0.36\ \Delta ADB_{t-1} - 0.63\ IGR$
(5.37) (14.83) (1.32) (3.37) (−3.47)
Std. error of regression = 0.360 R-squared = 0.983 Adjusted R-squared = 0.979
Rho (autocorrelation coef.) = −0.44 t-statistic for rho = −2.09

Railroad Infrastructure

(9) $IPAG = 1.88 + 0.81\ IPAG_{t-1} + 0.11\ \Delta Y_{t-1} + 0.33\ \Delta ADB_{t-1} - 0.46\ I\text{-}RA - 0.071$
(2.95) (12.70) (0.93) (2.60) (−1.12) (−2.88)
Std. error of regression = 0.369 R-squared = 0.984 Adjusted R-squared = 0.978
Rho (autocorrelation coef.) = −0.46 t-statistic for rho = −1.91

Federal Investment (IGFED)

(10) $IPAGP = 1.20 + 0.88\ IPAG_{t-1} + 0.12\ \Delta Y_{t-1} + 0.32\ \Delta ADB_{t-1} - 0.70\ IGFED$
(2.97) (5.34) (0.94) (1.95) (−0.40)
Std. error of regression = 0.475 R-squared = 0.960 Adjusted R-squared = 0.949
Rho (autocorrelation coef.) = −0.24 t-statistic for rho = −0.86

Federal Infrastructure (I-FED) and noninfrastructural investment (NI-FED)

(11) $IPAG = 0.77 + 0.82\ IPAG_{t-1} + 0.09\ \Delta Y_{t-1} + 0.36\ \Delta ADB_{t-1} + 0.09\ I\text{-}FED - 0.34\ NI\text{-}FED$
(2.18) (6.30) (0.83) (2.68) (0.54) (−2.45)
Std. error of regression = 0.408 R-squared = 0.976 Adjusted R-squared = 0.968
Rho (autocorrelation coef.) = −0.34 t-statistic for rho = −1.31881

Note: Statistics based on transformed data (TSP 1995). IPAG = private investment in agriculture; ΔY_{t-1} = lagged change in GDP; ΔADB_{t-1} = lagged change in credit from the agricultural development bank; I — measure of infrastructural component of investment; NI — measure of noninfrastructural component of investment.

Following Byerlee (1994) agricultural development in Pakistan can be conceptualized as occurring in four stages, distinguished by the sources of growth in each phase: (1) the pre-Green Revolution phase, with growth driven by (irrigated) area expansion, and productivity growth modest; (2) the Green Revolution phase, when growth was driven by high yielding varieties, with increased responsiveness to inputs; (3) the first post-Green Revolution phase with growth driven by intensification of input use, especially chemical fertilizer and irrigation water (which facilitates multiple cropping) and (4) the second post-Green Revolution phase, with input use beginning to plateau, and the source of growth becoming increased input efficiency, coupled with the ongoing release of new varieties of crops.

As is well known (Johnston 1970; Ruttan 1977), the Green Revolution shifts the production function upwards and raises the marginal responsiveness to inputs.

Farmers do not operate initially in the production frontier. In the first post-Green Revolution phase, use of complementary inputs rises, and farmers improve allocative efficiency (equalizing marginal products and prices). In the second post-Green Revolution phase, farmers encounter diminishing returns to inputs and move towards the production frontier by raising their efficiency. Here, resource degradation is a form of technical regress which will shift the production function downward.

Clearly the stage of development will affect the manner in which agricultural infrastructure affects the pattern of agricultural output. Extending the original ideas of Hirachman (1958), infrastructure development can initiate growth through subsidizing agriculture by lowering the costs for certain inputs used in production. This is the process referred to by Hirschman as development via excess capacity (of social overhead capital). Conversely lagging infrastructure may increase costs of production and result in slowing output and investment. In this situation the authorities are under pressure to expand infrastructure to "catch up" with the stock of directly productive capital.

With regard to the links between infrastructure and agricultural output, four patterns are theoretically possible:

1. *Infrastructure Causes Output*. This pattern is likely to reflect a situation where infrastructure is in excess (or nonconstraining) — the lower costs stemming from its provision results in increases in agricultural inputs and subsequent agricultural output. In this situation, infrastructure can be expected to have a high degree of linkage with productive factors, and thus produce a strong output response.
2. *Growth in Agricultural Output Causes Infrastructure*. Here infrastructure is lagging and responds to the needs created by previous agricultural growth. In this situation, infrastructure is likely to be a constraint on this output.
3. *A Feedback Relationship Between Output and Infrastructure*. Agricultural output and infrastructure may become interdependent, perhaps reflecting a situation whereby infrastructure is likely to be a binding constraint on growth. Once increased, infrastructure is adequate (relative to needs) to provide a positive stimulus to investment and or further output.
4. *No Relationship.* In this situation, infrastructure is not a constraint on agricultural growth, nor does it possess or create the type of linkages needed to induce increases in output in the sector.

If Pakistan is in the second post-Green Revolution phase we would expect that infrastructure investment would have a somewhat limited impact on output, with most of the gains in production coming from increased private efficiency. This is precisely the patterns found by the causality tests (Table 2).

1. With regard to the two types of infrastructure focused on agriculture, public works and Indus Basin, the pattern is one whereby infrastructure has a generally

Table 2

Pakistan: Summary of Infrastructure and Agricultural Output Patterns

Causal relationship	Time period	Direction of causation (sign of impact)	Optimal lag (years) strength
Public Works	1975-95	Inf→AG(−)	(1) Moderate
Indus Basin	1975-95	Inf→Ag(−)	(1) Weak
Electricity	1975-95	Feedback(+,+)	(1,1) W,M
Rail	1975-95	INF→AG(−)	(1) Weak
Federal	1975-95	AG→INF	(1) Strong

Notes: Summary of results obtained from Granger Causality Tests (Granger 1969) using a Hsaio Procedure with an initial four year lag structure (Hsiao 1981) to determine the optimal lag. Optimal lags are identified (Doan 1992) by the value of the final prediction error (Hsiao 1979). For example, using the final prediction error, infrastructure causes agricultural growth with the prediction error for agriculture falls when the equation includes infrastructure. In addition when agriculture is added to the infrastructure equation, the final prediction error increases.
All variables are in their log values and the series were found (Hansen and Juselius 1995) to be stationary (see Dickey and Fuller 1981).
For feedback the first relationship is the impact of infrastructure on agricultural output, while the second is the impact of agricultural output on infrastructure.

negative impact on output. The same is also the case for expansion of the country's rail system.

2. On the other hand energy infrastructure both has a positive impact on agricultural output and in turn is stimulated by increased production.
3. Finally, federal infrastructure responds strongly to increased agricultural output, however it has no subsequent effect in stimulating production in that sector.

These results are consistent with those found above (Table 1) and no doubt provide a further explanation as to the inability of infrastructure to stimulate private investment in the sector.

Conclusions

Given that the country is likely in the second post-Green Revolution phase of agricultural development and the limited effectiveness of the various types of infrastructure at increasing output, it is little wonder that the private investment is also unresponsive to increases in the provision of this type of public investment. This is not to say, however, that selective improvements in the quality of the country's rural infrastructure would not be beneficial in stimulating further investment and agricultural output.

One striking pattern is the generally low level of productivity in the country's agricultural sector. As the World Bank notes (IBRD 1994) however, neither absolute levels of productivity, nor productivity growth over time, have matched the progress on the input side. Various methods can be used to measure productivity, but most measures yield similar conclusions. Partial productivity measures (output per unit of a single factor) suggest (IBRD 1994) that productivity is much lower than comparable countries such as India and Egypt. Growth in yields has been very disappointing. For instance in the past decade, wheat yields have grown at 1.6 percent per annum compared to 2.9 percent in the Indian Punjab and 2.78 percent for all developing countries.

Even when inputs are used output is less than potential (IBRD 1994). For wheat, Byerlee and Siddiq found that yield growth was less than would be expected from the application of green revolution inputs (IBRD 1994). They attributed this to a decline in the quality of the resource base. Indicative of resource degradation is the fact that the yield of high yielding varieties in farmers' fields has not increases since 1970, despite the intensification of fertilizer use.

It is in this context that if infrastructure is to make a contribution to the country's agricultural sector, it will most likely be in terms of improved quality of facilities and efficient management rather than their simple expansion (Beg 1995).

REFERENCES

BEG, M.A.A.

1995 "Infrastructure Facilities: A Vital Component to Economic Growth." *Pakistan & Gulf Economist* September 23:7-14.

BLEJER, M.I. and M.S. KHAN

1985 "Public Investment and Crowding Out in the Caribbean Basin Countries." Pp. in *The Economics of the Caribbean Basin Countries*, edited by M. Connolly and J. McDermott. New York: Praeger.

BOKHARI, F.

1996 "Pakistani Cotton Farmers Play for High Stakes: The Success of the Crop is Vital for the Country's Economy." *Financial Times* July 26, p. 26.

1996a "Pakistan Set to Grasp Farm Tax Nettle." *Financial Times* June 13, p. 19.

1996b "Taxpayers Sought to Fill Pakistan's Budget Hole." *Financial Times* June 13, p. 6.

BYERLEE, D.

1994 *Agricultural Productivity in Pakistan: Problems and Potential*. Washington: World Bank.

CHAUDHRY, M.H.

1995 "Economic Liberalization of Pakistan's Economy: Trends and Repercussions." *Contemporary South Asia* 4(2):187-192.

DICKEY, D.A. and W.A. FULLER

1981 "Likelihood Ration Statistics for Autoregressive Time Series With a Unit Root." *Econometrics* 49:1057-1072.

DOAN, T.A.

1992 *RATS User's Manual Version 4*. Evanston, Illinois: Estima.

ESCAP

1991 *Economic and Social Survey of Asia and the Pacific, 1990*. New York: United Nations.

GOP

1995 *Economic Survey 1994-95*. Islamabad: Finance Division, Economic Advisor's Wing.

GRANGER, C.W.J.

1969 "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods." *Econometrica*:424-438.

HAMID, I.N. and A. NASIM

1990 *Trade, Exchange Rate, and Agricultural Pricing Policies in Pakistan*. Washington: The World Bank.

HANSEN, H. and K. JUSELIUS

1995 *CATS in RATS: Cointegration Analysis of Time Series*. Evanston, Illinois: Estima.

HIRSCHMAN, A.O.

1958 *The Strategy of Economic Development*. New Haven, CT: Yale University Press.

HSIAO, C.

1979 "Causality Tests in Econometrics." *Journal of Economic Dynamics and Control* 7:326-335.

1981 "Autoregressive Modeling and Money-Income Causality Detection." *Journal of Monetary Economics*:85-106.

IBRD

1983 *Pakistan: Review of the Sixth Five-Year Plan.* Washington: The World Bank.

1991 *Pakistan: Current Economic Situation and Prospects.* Washington: The World Bank.

1992 *Pakistan: Current Economic Situation and Prospects.* Washington: The World Bank.

1993 *Pakistan: Country Memorandum FY93, Progress Under the Adjustment Program.* Washington: The World Bank.

1994 *Pakistan: A Strategy for Sustainable Agricultural Growth.* Washington, DC: World Bank.

1994a *Pakistan Irrigation and Drainage: Issues and Options.* Washington, DC: World Bank.

1995 *World Development Report, 1995*. New York: Oxford University Press.

ISLAM, S. and A. RASHID

1996 "Talking Tough: Donors Tell Pakistan to Clean Up Its Fiscal Act." *Far Eastern Economic Review* May 3, 159:77.

JOHNSTON, B.F.

1970 "Agriculture and Structural Transformation in Developing Countries: A Survey of Research." *Journal of Economic Literature* VIII(2):369-404.

KHAN, A.

1988 "Macroeconomic Policy and Private Investment in Pakistan." *The Pakistan Development Review* 27(3):277-94.

KHAN, A. and Z. IQBAL

1991 "Fiscal Deficit and Private Sector Activities in Pakistan." *Economia Internazionale* 44(2-3):182-90.

KHAN, M.H.

1985 "Public Policy and Agricultural Transformation in Pakistan." *The Pakistan Development Review* XXIV(3 & 4):305-329.

LEFF, N.H. and K. SATO

1980 "Macroeconomic Adjustment in Developing Countries: Instability, Short-run Growth and External Dependency." *The Review of Economics and Statistics* LXII(2):170-179.

LOONEY, R.E.

1995 "Public Sector Deficits and Private Investment: A Test of the Crowding-out Hypothesis in Pakistan's Manufacturing Industry." *The Pakistan Development Review* 34(3):277-299.

1995a "Macroeconomic Constraints on Private Sector Investment in Pakistan." *METU Studies Development* 22(4):397-424.

1994 "Manufacturing's Contribution to Pakistan's Economic Expansion." *Development Policy Review* 12(4):369-386.

1994a "The Impact of Infrastructure on Pakistan's Agricultural Sector." *Journal of Developing Areas* 28(July):469-486.

1992 "Budgetary Balance and Private Sector Activity in Pakistan: The Net Impact of Defense Expenditures on Investment in Manufacturing." *Journal of Economics and Administrative Sciences* 6:83-111.

1992a "Infrastructural Constraints on Transport and Communications: The Case of Pakistan." *International Journal of Transport Economics* XIX(3):287-306.

LOONEY, R.E. and D. WINTERFORD

1992 "The Roe of Infrastructure in Pakistan's Economic Development: 1972-1991." *Pakistan Economic and Social review* XXX(1):69-94.

RUTTAN, V.W.

1977 "The Green Revolution: Seven Generalizations." *International Development Review* XIX(4):16-23.

SCHIANTARELLI, F.

1996 "Financial Constraints and Investment: Methodological Issues and International Evidence." *Oxford Review of Economic Policy* 12(2):70-89.

TSP

1995 *TSP Reference Manual: Version 4.3*. Palo Alto, California: TSP International.